









Kurt Becker

John Gero

Julie Milovanovic

Udo Kannengiesse Udo Kannengiesser

Proofing a basic systems engineering model through empirically-based cognitive testing

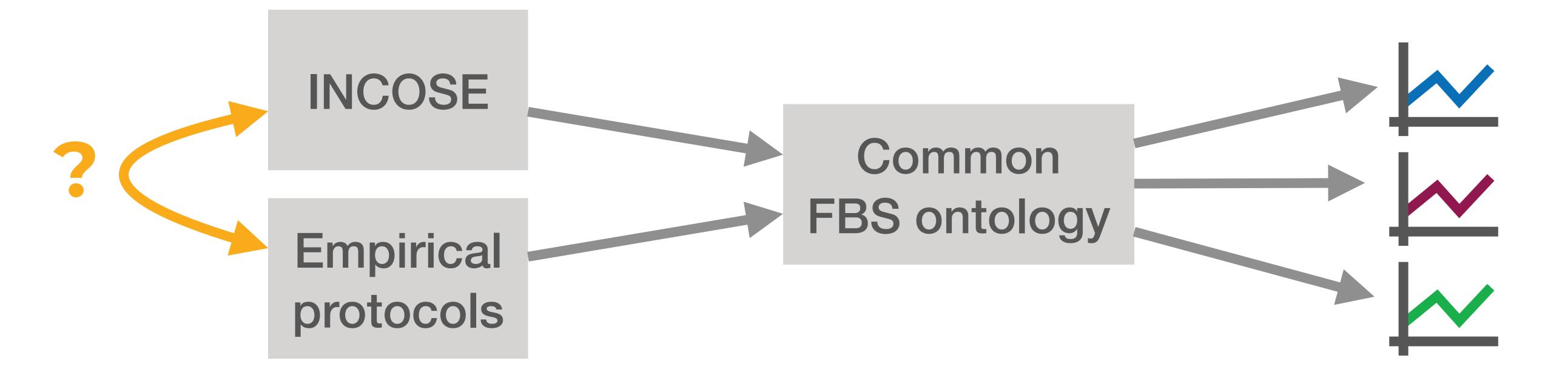
Background

The scientific study of engineering systems and design requires both theoretical models and empirical testing. This research addresses the gap in our knowledge of testing theoretical descriptive models of engineering systems design with design behavior derived from empirical studies.

Methods

This project develops a cognitive characterization of engineering systems and design (ESD) through an empirical protocol analysis of teams of professional systems engineers designing under controlled conditions and compares it to the INCOSE engineering systems design descriptive model.

- 1) Collect empirical protocols
- 2) Coding protocols and INCOSE
- 3) Modelling design cognitive behaviors / descriptive model



Acknowledgement



This material is based upon work supported by the National Science Foundation (NSF) under Grant Nos. Nos. EEC-1463809 and EEC-1463873. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of USAID.

The main finding is this...

Results

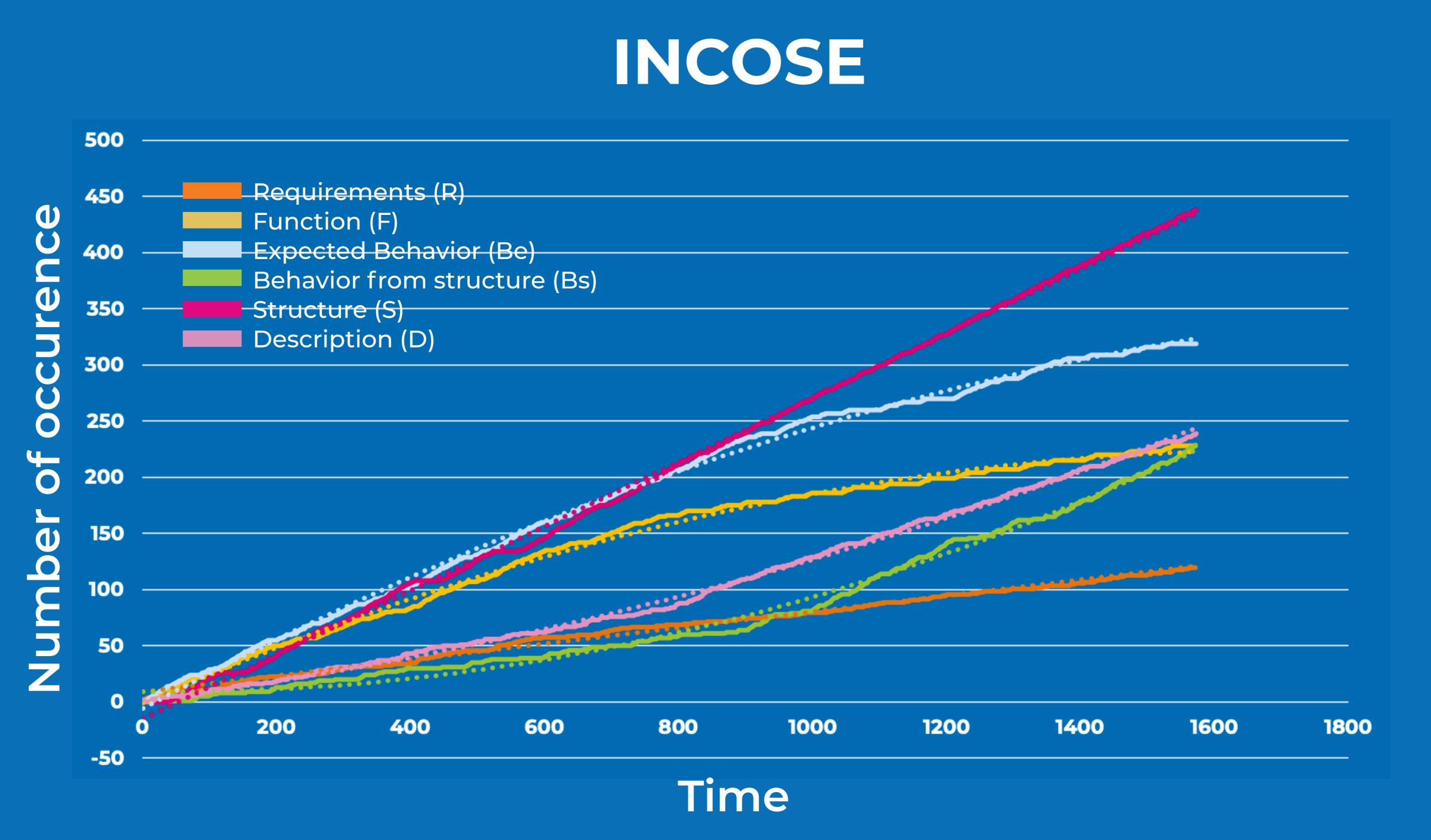


Figure 1. INCOSE cumulative occurrences of design issues

Table 1. Markov model of design issue transitions for INCOSE descriptive model

| | R | F | Be | Bs | S | D |
|----|-------|-------|-------|-------|-------|-------|
| R | 0.03* | 0.58 | 0.13 | 0.08 | 0.17 | 0.00* |
| F | 0.02* | 0.00* | 0.77 | 0.14 | 0.04* | 0.04* |
| Be | 0.04 | 0.11 | 0.05 | 0.02* | 0.69 | 0.09 |
| Bs | 0.04 | 0.03* | 0.02* | 0.11 | 0.49 | 0.30 |
| S | 0.08 | 0.19 | 0.18 | 0.33 | 0.03 | 0.18 |
| D | 0.22 | 0.14 | 0.11 | 0.04 | 0.27 | 0.22 |

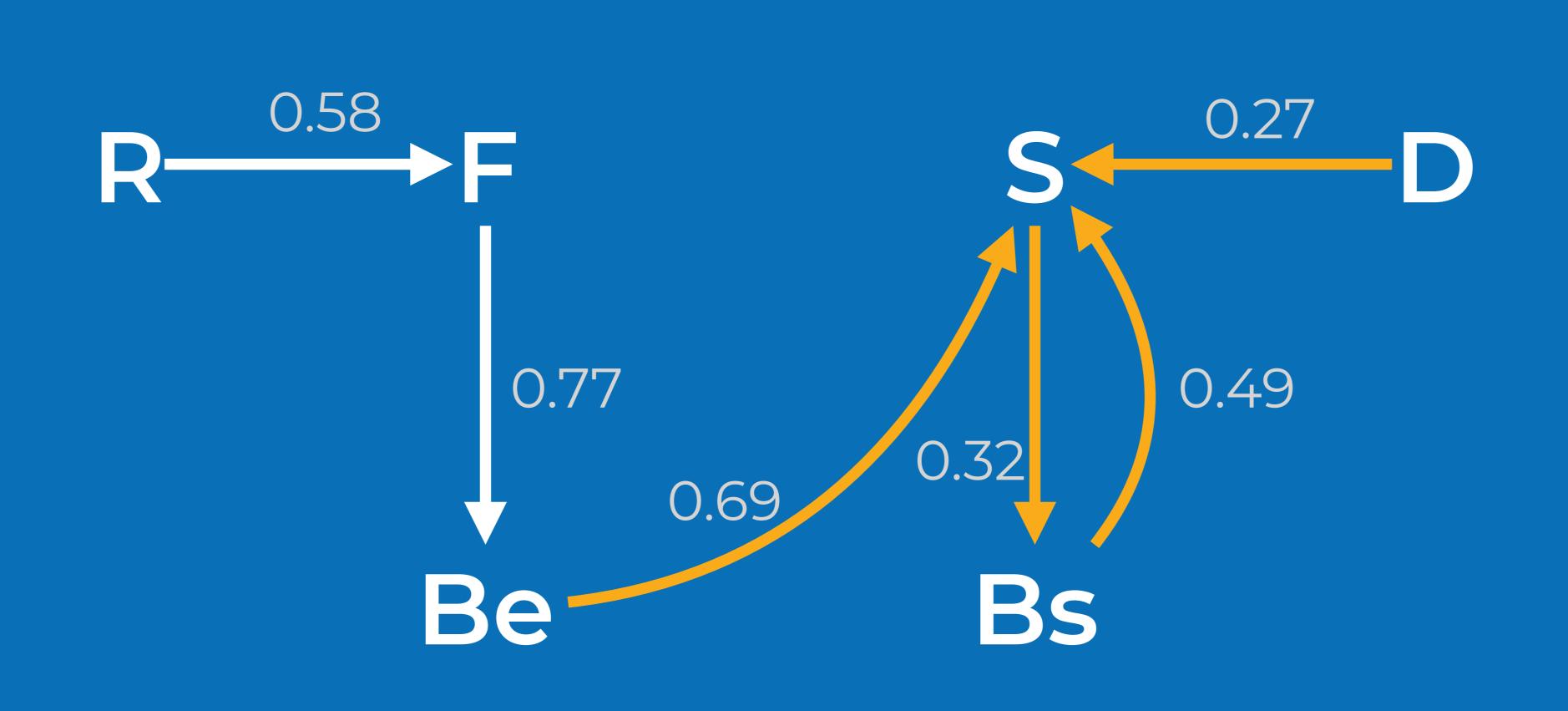


Figure 3. INCOSE FBS design patterns

EMPIRICAL PROTOCOL

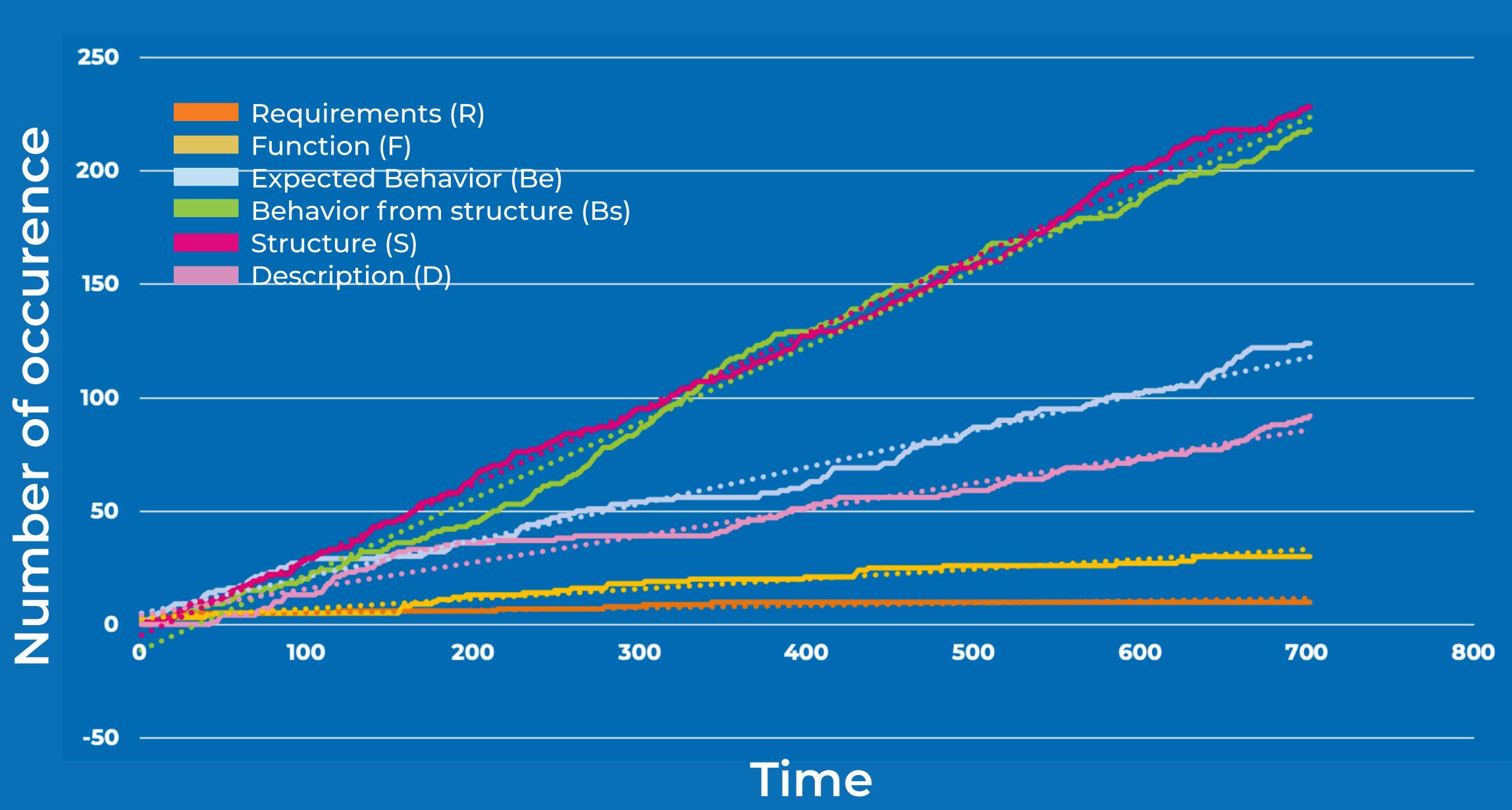


Figure 2. Empirical protocol cumulative occurrences of design issues

Table 2. Markov model of design issue transitions for empirical protocol descriptive model

| | R | | Be | Bs | S | |
|----|------|------|------|------|------|------|
| R | 0.00 | 0.20 | 0.20 | 0.20 | 0.30 | 0.10 |
| F | 0.00 | 0.23 | 0.20 | 0.27 | 0.27 | 0.03 |
| Be | 0.03 | 0.06 | 0.27 | 0.22 | 0.28 | 0.14 |
| Bs | 0.02 | 0.01 | 0.15 | 0.33 | 0.36 | 0.14 |
| S | 0.00 | 0.03 | 0.14 | 0.38 | 0.32 | 0.12 |
| | 0.01 | 0.03 | 0.20 | 0.26 | 0.33 | 0.16 |

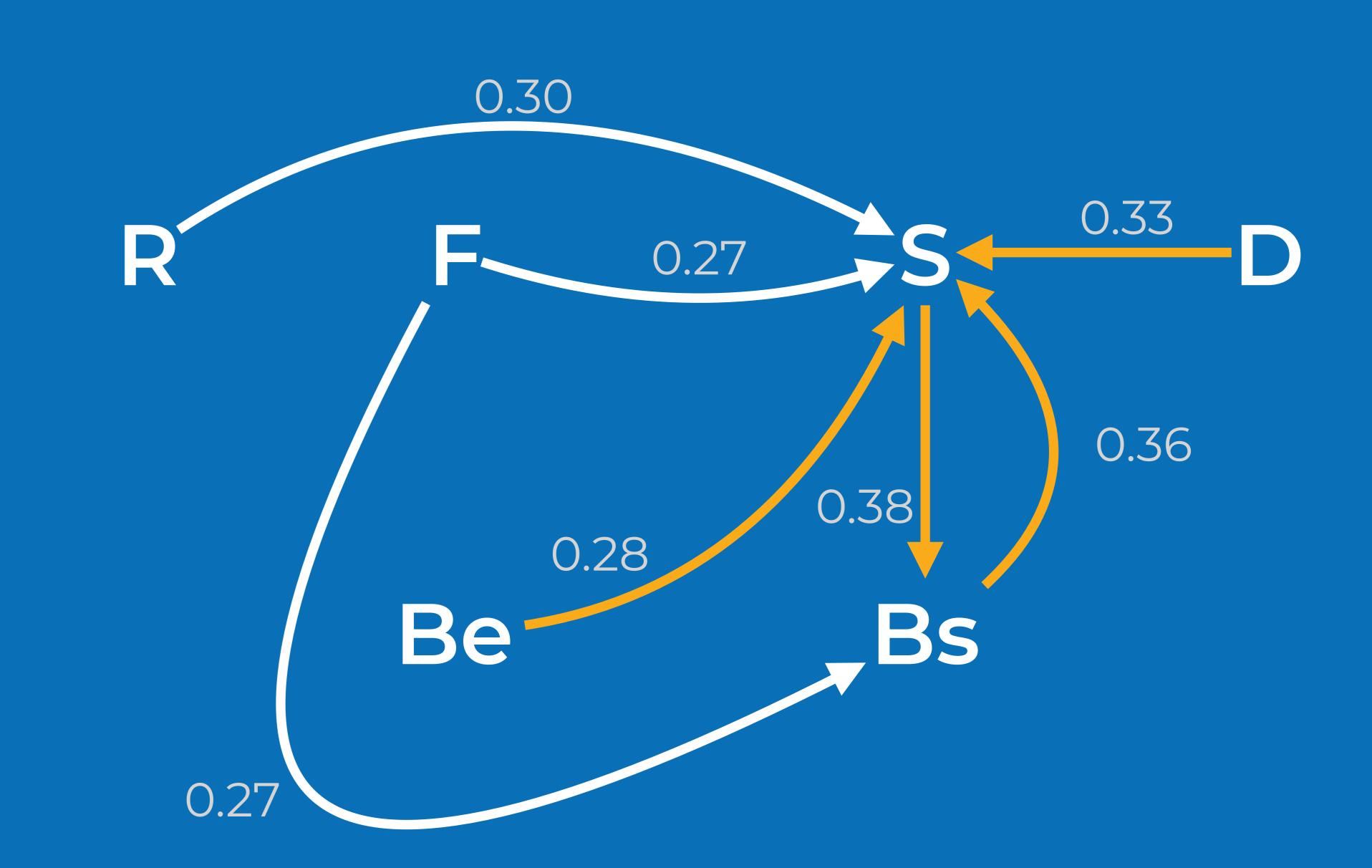


Figure 4. Empirical protocol FBS design patterns